

PROGRAMMING DOCUMENTS

**ENERGY ENGINEERING
ANALYSIS PROGRAM**

**ENERGY SURVEY OF BOILER
AND CHILLER PLANTS**

YUMA PROVING GROUND, ARIZONA

PREPARED FOR

**DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA**

PREPARED BY

**KELLER & GANNON
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1453 MISSION STREET, SAN FRANCISCO, CA 94103**

CONTRACT NO. DACA 05-C-92-0155

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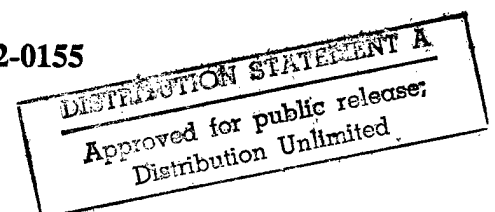


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1. COMPONENT Army		FY 1996 MILITARY CONSTRUCTION PROJECT DATA		2. DATE October 1994	
3. INSTALLATION AND LOCATION Yuma Proving Ground, Arizona			4. PROJECT TITLE ECIP Facility Energy Improvements		
5. PROGRAM ELEMENT	6. CATEGORY CODE 80000	7. PROJECT NUMBER	8. PROJECT COST (\$000) 655.2		
9. COST ESTIMATES					
Item		U/M	Quantity	Unit Cost	Cost (\$000)
Primary Facility					514.1
Replace boilers with modular units		LS	—	—	(99.5)
Install chilled water temperature reset controls		LS	—	—	(24.6)
Replace 45 ton glycol chiller		LS	—	—	(50.8)
Manifold chillers		LS	—	—	(46.5)
Install duty cycling controls on chillers		LS	—	—	(5.3)
Retrofit lighting fixtures		LS	—	—	(233.1)
Install occupancy sensor light fixture switching		LS	—	—	(41.9)
Install light fixture switching		LS	—	—	(12.4)
Supporting Facilities					0
Estimated Contract Cost					514.1
Contingency (10%)					51.4
Subtotal					565.5
Supervision, Inspection and Overhead (6%)					33.9
Unescalated CWE					599.4
Escalation to FY 1996					55.8
Total Request					655.2
10. DESCRIPTION OF PROPOSED CONSTRUCTION					
Perform the following energy conservation and cost-saving retrofits:					
a. Replace two steam boilers with one modular hot water boiler system in Building 506.					
b. Install chilled water temperature reset controls on three chillers (one in Building 506 and two in Building 2105).					
c. Replace the converted 45-ton glycol chiller for ice-on-coil system at Building 506 with an efficient unit designed for cold-temperature applications.					
d. Install duty cycling controls on four chillers (one in Building 451 and three in Building 3490).					
e. Modify lighting fixtures and install lighting controls as follows:					
(1) Retrofit fluorescent fixtures with electronic ballasts and T8 lamps in Buildings 451, 506A, 506B, 506C, 2105 and 3490.					
(2) Retrofit 4-lamp fluorescent fixtures with 3-lamp electronic ballasts, T8 lamps and specular reflectors in Buildings 451, 506B, 2104 and 3490.					
(3) Replace incandescent fixtures with surface mounted T8 and compact fluorescent fixtures in Buildings 451, 506A and 506B.					
f. Install occupancy sensors (ceiling or wall-switch mounted) in Buildings 451, 506A, 506B, 2105 and 3490.					
g. Install additional explosion-proof light fixture switching in Building 3482.					

DD FORM 1391

PROJECT: Implement energy conservation retrofits in six buildings. (Current mission.)

REQUIREMENT: This project will contribute toward achieving Department of Defense facility energy goals of a 20-percent reduction in energy use per gross square feet by FY2000 versus FY1985 baseline levels.

This project will save \$119,952 annually, resulting in a 5.3-year simple payback period and a savings-to-investment ratio of 2.64. The annual energy savings is 3,321 MBTU (3,503,000 MJ) of electricity, 466 MBTU (34,263 MJ) of fuel oil and 578 MBTU (39,543 MJ) of LPG fuel. All buildings and retrofit actions will be in active use throughout the amortization period.

CURRENT SITUATION: Unnecessary energy is currently being consumed for space heating and cooling systems, lighting systems, and generation of domestic hot water in facilities.

IMPACT IF NOT PROVIDED: If this project is not accomplished, an annual energy and operations and maintenance expense of \$119,952 that could be avoided will be incurred.

ADDITIONAL: This project has been coordinated with the installation physical security plan, and no security improvements are required. This project incorporates recommendations of an Energy Engineering Analysis Program, Energy Survey of Boiler and Chiller Plants, performed under Contract No. DACA05-92-C-0155.

This installation is not under consideration for realignment or closure.

RICHARD R. WALKER
Colonel, Aviation
Commanding

Estimated Construction Start: July 1996

Estimated Midpoint of Construction: September 1996

Estimated Construction Completion: November 1996

Index: 2119

Index: 2133

Index: 2147

Detailed Justification

1. GENERAL: The project is a significant part of Yuma Proving Ground's effort to achieve a 20-percent reduction in energy consumption by FY2000 versus FY1985 baseline levels.
2. ACCOMMODATIONS NOW IN USE: Not applicable.
3. ANALYSIS OF DEFICIENCY: Present system designs within the facilities proposed for retrofits account for an unnecessary annual energy and operations and maintenance expense of \$119,952 that could be avoided.
4. CONSIDERATION OF ALTERNATIVES: The retrofits included in this project represent all of the economically justified actions potential energy conservation opportunities (ECO's) evaluated in the Energy Survey of Boiler and Chiller Plants that comply with ECIP criteria.
5. CRITERIA FOR PROPOSED CONSTRUCTION: Design and construction will be in accordance with criteria established in DOD 4270.1-M and TM810-5.
6. PROGRAM FOR RELATED FURNISHINGS AND EQUIPMENT: Not applicable.
7. DISPOSAL OF PRESENT ASSETS: Not applicable.
8. SURVIVAL MEASURES: Not applicable.
9. SUMMARY OF ENVIRONMENTAL CONSEQUENCES: Atmospheric emissions will be reduced because less fuel will be burned as a result of implementation of this project.
10. EVALUATION OF FLOOD HAZARDS AND ENCROACHMENT ON WETLANDS: Not applicable.
11. ECONOMIC JUSTIFICATION: In accordance with Energy Conservation Investment Program (ECIP) Guidance dated November 1992, an economic analysis has been prepared. Life-cycle cost analysis results are summarized as follows:

• Estimated Construction Cost (including SIOH)	\$599,400
• Annual Energy Savings	4,365 MBTU (3,577,000 MJ)
• Total First Year Dollar Savings	\$119,952
• Discounted Energy Savings	\$1,300,298
• Discounted Nonenergy Savings	\$369,544
• Total Net Discounted Savings	\$1,669,842
• Savings-to-Investment Ratio	2.64

Refer to "Detailed Calculations" for backup data.

12. UTILITY AND TELECOMMUNICATIONS SUPPORT: Not applicable.

13. PROTECTION OF HISTORIC PLACES AND ARCHEOLOGICAL SITES: Review procedures have been implemented for this project in accordance with 36 CFR 800. The review has established that there will be no effect.
14. PROJECT DEVELOPMENT BROCHURE: A Project Development Brochure (PDB-1) dated October 1994 has been prepared.
15. ENERGY REQUIREMENTS: Not applicable.
16. PROVISION FOR THE HANDICAPPED: Not applicable.
17. REAL PROPERTY MAINTENANCE ACTIVITY ANALYSIS: Not applicable.
18. COMMERCIAL ACTIVITIES: This project involves replacement or modification of existing systems for energy conservation. Under these conditions, the provisions of AR 5-XX do not apply, and a "new start or expansion" is not required.

Life Cycle Cost Analysis Summary Energy Conservation Investment Program (ECIP)

Location: Yuma Proving Ground, Arizona Region No. 4 Project No.
Project Title: ECIP Facility Energy Improvements - Total Project Fiscal Year FY96
Analysis Date: January 1994 Economic Life: 15 & 20 Years Preparer: KELLER & GANNON

1. Investment Costs

A. Construction Costs	\$ 565,547	
B. SIOH	\$ 33,933	
C. Design Cost	\$ 33,933	
D. Total Cost (1A + 1B + 1C)	\$ 633,413	
E. Salvage Value of Existing Equipment		\$1,206
F. Public Utility Company Rebate		\$0
G. Total Investment (1D-1E-1F)		\$632,207

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273 Used for Discount Factors: October 1993

Energy Source	Cost \$/MBTU(1)	Saving MBTU/Yr(2)	Annual \$ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec. 15 Year	\$24.32	2,231	\$54,260	12.49	\$677,707
B. Elec. 20 Year	\$24.32	1,090	\$26,511	15.64	\$414,631
C. Dist 20 Year	\$13.25	466	\$6,174	17.47	\$107,866
D. LPG 20 Year	\$7.37	578	\$4,263	19.21	\$81,884
E. Other					
F. Demand Savings	\$31.68/kW	36.75 kW	\$1,164	15.64	\$18,210
G. Total		4,366	\$92,372		\$1,300,298

Demand savings are based on \$1.98/kW/Mo @ 6 Months + 10 times rate for 1 Mo.; 20 year life.

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	15 Years	\$12,796	\$27,580	Total per Year
	20 Years	\$14,784		
(1) Discount Factor (Table A)	15 Years		11.85	
	20 Years		14.74	
(2) Discounted Savings/Cost (3A x 3A1)				\$369,544

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+) Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2 + 3Bd4) \$369,544

4. First Year Dollar Savings (2G3 + 3A + (3Bd1/Years Economic Life)):	\$119,952	
5. Simple Payback (1G/4):	5.27	Years
6. Total Net Discounted Savings (2F5 + 3C):	\$1,669,842	
7. Savings to Investment Ratio (SIR) 5/1G:	2.64	

Summary of DD 1391 Energy-Saving Project Elements

Element Description	Energy Savings			Total Equivalent MBTU/Yr	Cost Savings		Investment \$	SIR
	Fuel Oil MBTU/Yr	LPG MBTU/Yr	Electric MBTU/Yr		\$/Yr	LCC \$		
Replace Boilers with Modular Units, Building 506	466	578	---	1,044	28,255	452,382	122,560	3.69
Install Chilled Water Temperature Reset Controls (Buildings 506 and 2105)	---	---	500	500	10,582	166,935	30,304	5.51
Replace Glycol Chiller, Building 506	---	---	273	273	6,640	103,850	62,606	1.66
Manifold Chillers at Building 3490	---	---	317	317	6,384	101,041	57,321	1.76
Install Duty Cycling Controls ⁽¹⁾	---	---	---	---	1,032	16,265	6,524	2.49
Retrofit Lighting Fixtures	---	---	1,657	1,657	53,099	655,018	286,017 ²	2.29
Install Occupancy Sensor Switching	---	---	469	469	11,410	142,512	51,655	2.76
Install Light Fixture Switching, Building 3482	---	---	105	105	2,546	31,805	15,220	2.09
TOTALS	466	578	3,321	4,365	119,952	1,669,842	632,207	2.64

Notes:

1. Electric load savings during peak demand total 36.8 kW.
2. Includes Arizona Public Service Co. rebate of \$1,206.

Location: Yuma Proving Ground, Arizona
Project Title: ECIP Facility Energy Improvements

DETAILED CALCULATIONS

Life Cycle Cost Analysis Summary Energy Conservation Investment Program (ECIP)

Location: Yuma Proving Ground, Arizona Region No. 4 Project No.
Project Title: ECIP Facility Energy Improvements Fiscal Year FY96
 Bldg 506 Modular Boilers for Heating & DHW Service
Analysis Date: January 1994 Economic Life: 20 Years Preparer: KELLER & GANNON

1. Investment Costs

A. Construction Costs	\$ 109,429	
B. SIOH	\$ 6,566	
C. Design Cost	\$ 6,566	
D. Total Cost (1A+1B+1C)	\$ 122,560	
E. Salvage Value of Existing Equipment	\$0	
F. Public Utility Company Rebate	\$0	
G. Total Investment (1D-1E-1F)		\$122,560

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273 Used for Discount Factors: October 1993

Energy Source	Cost \$/MBTU(1)	Saving MBTU/Yr(2)	Annual \$ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	\$0.00	0.0	\$0	15.64	\$0
B. Dist	\$13.25	466	\$6,173	17.47	\$107,849
C. LPG	\$7.37	578	\$4,262	19.21	\$81,866
D. Other					
E. Demand Savings					
F. Total		1044	\$10,435		\$189,715

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	\$17,820	
(1) Discount Factor (Table A)	14.74	
(2) Discounted Savings/Cost (3A x 3A1)		\$262,667

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2 + 3Bd4) \$262,667

4. First Year Dollar Savings (2F3 + 3A + (3Bd1/Years Economic Life)):	\$28,255	
5. Simple Payback (1G/4):	4.34	Years
6. Total Net Discounted Savings (2F5 + 3C):	\$452,382	
7. Savings to Investment Ratio (SIR) 5/1G:	3.69	

Replace Boilers with Modular Units, Building 506 - Detailed Calculations

Existing boilers each have a capacity to generate 4,315 pounds per hour of steam. Steam is used to heat hot water in heat exchangers for space heating and for domestic hot water (DHW). Steam was used previously for cooking and dishwashing in the dining facility. (Dining facility is no longer used for this purpose.)

Existing boilers are oversized for their present use. The lack of use of the dining facility and changes in use from a dormitory to office functions for part of the building causes heat load to be reduced. Additional savings in heating load are provided by the recent addition of exterior wall insulation.

Installation of smaller boilers to accomodate non-heating season heating needs will reduce losses from boiler cycling and provide heating at efficiencies only available with modern boilers.

Energy Savings Calculation

Efficiencies, comparable to those developed above, of modular boiler installation (@ Hydrotherm) is 76.6% on No. 2 Fuel Oil and 75.8% on Natural Gas/LPG. Compared to existing efficiencies and energy use:

	LPG	No 2 FO	Total
Existing Energy Use (Mil BTU/Yr)	1,496	1,615	3,111
Existing Avg. Plant Efficiency	46.5%	54.5%	50.5%
Existing Plant Load (Mil BTU/Yr)	696	880	1,576
Improved Plant Efficiency	75.8%	76.6%	-
Future Energy Use (Mil BTU/Yr)	918	1,149	2,067
Energy Savings (Mil BTU/Yr)	578	466	1,044
Energy Costs (\$/Mil BTU)	\$7.37	\$13.25	-
Energy Cost Saved (\$/Year)	\$4,262	\$6,173	\$10,435
LCC UPW Factor; N = 15 Years	19.21	17.47	Region 4, Industrial
LCC Fuel Costs Saved (\$)	\$81,866	\$107,849	\$189,715

O&M Cost Savings

One operator attends existing steam boilers a minimum of 3 hours per day, 5 days per week. Use of new HW boilers does not require operator attendance. Annual labor cost savings are calculated assuming 780 Hrs/Yr, \$22/Hr x 1.5 for benefits/OH:

\$25,740 per year saved from existing operator

Assume 240 Hr/Yr maintenance is required for new boilers and for existing boilers, to be kept moth-balled.

(\$7,920) per year maintain existing & new systems

Net O&M Savings =	\$17,820 per Year
LCC UPV Factor; N = 20 Years	14.74
LCC O&M Costs Saved	\$262,667

New Boiler Sizing

Existing boilers are sized at 4,315 #/Hr steam production; 4,187,500 BTUH output.
As shown in ECO B1 calculations, average existing plant efficiency is 50.5%. Thus, design
load per boiler is: $4.1875 / 0.505 = 8.29$ Million BTUH

0.505

Building use has changed:

- Fewer residents
- Some rooms changed to offices
- Dining facility is closed
- Exterior wall insulation added to building
- Roof insulation added

Significantly reduced loads resulting from these changes causes existing steam
boilers to cycle frequently.

Domestic Hot Water generator loads include dining facility and residents. With a
population of 200 residents and 30 gpcd of 140 Deg F Hot Water use (60 Deg F CW
temperature assumed):

4.008 Million BTU/Day Load

Assume 2.004 Million BTUH Load (conservative)

Load reduction due to wall insulation: Assume $U = 0.40$ for wall before insulation
added and $U = 0.05$; energy savings are:

36,000 SF Wall Area

70 - 39 Deg F 31 Deg F Delta T

390,600 BTUH load saved from Wall Insulation

Population DHW Load Reduction: Population reduced to 50% from design:

1.002 Million BTUH Load reduction

Non-use of dining facility: Booster heater uses 185 Deg F water, steam uses in
cooking kettles, dishwashing, etc, account for about:

1.5 Million BTUH Load reduction

Overall Load Reduction = 2.893 Million BTUH Total Load reduction

Assuming the original boiler plant was sized for 150% of total load, the original load
for heating and DHW heating is: 5.583 Million BTUH Original DHW Load

The new, reduced load for heating and DHW is: $(2 \times 4.1875 \text{ MBTUH} / 1.5)$
Replaces existing boilers until - 2.893 MBTU =
dining facility reopened 2.691 Million BTUH New, Reduced Load
DHW and Heating Services

CONSTRUCTION COST ESTIMATE					Date Prepared January 1994		Sheet Of 1 1	
Project ECIP Facility Energy Improvements					Project No.		Basis for Estimate Code A (no design competed)	
Location Yuma Proving Ground, Arizona								
Engineer-Architect Keller & Gannon								
Drawing No. Modular Boiler, Building 506				Estimator JRB		Checked By BIH		
Line Item	Quantity		Labor		Material		Total Cost	
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total		
MOP-3850-10Mod Hydrotherm HW Boiler	1	EA	\$9,400	\$9,400	\$30,015	\$30,015	\$39,415	
Burners BM-4133 Dual	10	EA	\$300	\$3,000	\$2,600	\$26,000	\$29,000	
4" Dia. Pipe-Allow. (Galv.) 151-701-2110	200	LF	\$11	\$2,276	\$9	\$1,890	\$4,166	
Circulation Pump Base Mounted	2	EA	\$255	\$510	\$1,250	\$2,500	\$3,010	
Gate Valves 4" Dia.	12	EA	\$136	\$1,632	\$345	\$4,140	\$5,772	
Misc. Controls	-	Lot	-	\$1,000	-	\$2,000	\$3,000	
Shed - Enclosure	240	SF	\$50	\$12,000	\$25	\$6,000	\$18,000	
Flue/Stack 48" Dia.	70	LF	\$33	\$2,275	\$380	\$26,600	\$28,875	
Pipe Insulation 4" Dia. 2" Thick	200	LF	\$6	\$1,190	\$5	\$1,090	\$2,280	
Electrical - Allowance	-	Lot	-	\$2,000	-	\$1,000	\$3,000	
Subtotal				\$14,676		\$57,905	\$72,581	
State Sales Tax	5.5%	%		-		\$3,185	\$3,185	
Subtotal							\$75,766	
Contractor OH & Profit	30.0%	%					\$22,730	
Subtotal							\$98,496	
Bond	1.0%	%					\$985	
Subtotal							\$99,480	
Estimating Contingency	10.0%	%					\$9,948	
Total Probable Construction Cost							\$109,429	

Life Cycle Cost Analysis Summary

Energy Conservation Investment Program (ECIP)

Location: Yuma Proving Ground, Arizona Region No. 4

Project No.

Project Title: ECIP Facility Energy Improvements

Fiscal Year FY96

Chilled Water Temperature Reset Controls

Analysis Date: January 1994 Economic Life: 20 Years

Preparer: KELLER & GANNON

1. Investment Costs

A. Construction Costs	\$ 27,057	
B. SIOH	\$ 1,623	
C. Design Cost	\$ 1,623	
D. Total Cost (1A + 1B + 1C)	\$ 30,304	
E. Salvage Value of Existing Equipment	\$0	
F. Public Utility Company Rebate	\$0	
G. Total Investment (1D-1E-1F)		\$30,304

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost \$/MBTU (1)	Saving MBTU/Year(2)	Annual \$ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	\$24.32	500.3	\$12,166	15.64	\$190,284
B. Dist	\$0.00	0.00	\$0.00	17.47	\$0
C. LPG	\$0.00	0.00	\$0.00	19.21	\$0
D. Other					
E. Demand Savings					
F. Total		500	\$12,166		\$190,284

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	(\$1,584)	
(1) Discount Factor (Table A)	14.74	
(2) Discounted Savings/Cost (3A x 3A1)		(\$23,348)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+) Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2 + 3Bd4) (\$23,348)

4. First Year Dollar Savings (2F3 + 3A + (3Bd1/Years Economic Life))	\$10,582	
5. Simple Payback (1G/4):	2.86	Years
6. Total Net Discounted Savings (2F5 + 3C):	\$166,935	
7. Savings to Investment Ratio (SIR) 5/1G:	5.51	

Install Chilled Water Temperature Reset Controls - Detailed Calculations

Introduction:

Raising the chilled water temperature, or evaporator temperature, will reduce compressor load, and thus, energy consumption. The chiller Coefficient of Performance (COP) is improved, for example, reciprocating chiller efficiency is increased by up to 5.8% for a 5 Degree increase in chilled water supply temperature.

Chiller & Refrigeration Systems Evaluated:

Chiller systems evaluated and found to be feasible for this retrofit include the following:

Bldg No.	Refrig. Tons	Remarks
506	220	Centrifugal - Water Cooled Condenser
2105 C1	125	Centrifugal - Water Cooled Condenser
2105 C5	125	Centrifugal - Water Cooled Condenser

Energy Saving Calculations:

Existing chiller performance is based on field measurements of load and power demand of partially loaded chillers and on catalog performance data.

The energy savings for chilled water reset were calculated by taking all the instances in which the outdoor ambient temperature was below 75°F and, if there was a chiller demand, raising the leaving chilled water temperature from one to five degrees. The assumption was made that in instances when the outdoor temperature was below 75°F, the chilled water temperature could be raised and still satisfy the cooling load at the same flow rate. Calculations used for developing the accompanying spread sheet and graphical analyses (See Figures 1 through 3) for each chiller follow:

Abbreviations:

BTU	British Thermal Unit
BTUH	British Thermal Units per Hour
KW	Kilowatts (Field measurement of chiller load)
KWH	Kilowatt hours
EER	Energy Efficiency Ratio (BTUH out + Watts in)
T_r	Chilled Water Temperature Rise (For Saving Calculations) (°F)
T_{OA}	Outside Air Temperature Rise (Field measurement) (°F)
ΔT	Temperature Differential (Field measurement) (°F)
GPM	Gallons per minute (Field measurement)
Cooling Factor	Ratio of Annual Hours below 75°F to measurement period hours below 75°F + 365.
EER	If $(GPM \times 500 \times \Delta T) > 0$, Then: $EER = BTU + (KWH/1000)$
BTUH (Load)	$GPM \times 500 \times \Delta T$

Energy Saving Calculation:

The following are calculated for 5 minute measurement periods; results are averaged or totaled, as needed, to determine savings during that time and are then extended to annual savings using the Cooling Factor.

BTUH	If $(T_{OA} < 75^\circ F)$ and If $(Load) > 0$, Then: Savings (BTUH) = Load - $(500 \times (\Delta T - T_r) \times GPM)$
KW	If $(EER) > 0$, Then: $KW = (BTUH + EER) + 1,000$
KWH/Day	$KW \times (5 \text{ Minute measurement} + 60 \text{ Minutes per Hour}) \times \text{Cooling Factor}$
KWH/Year	$KWH/Day \times 365 \text{ Days/Year}$

Cooling Factor Calculation:

Bldg No.	Analysis Hr<75°F	Annual Hr<75°F	Cooling Factor
506	14.67	5,236	0.978
2105 C1	5.68	5,236	2.526
2105 C5	5.68	5,236	2.526

Annual hours below 75°F are from TM 5-785. Analysis hours below 75°F are based on field measurements.

Cost Saving Calculation:

Annual energy cost savings are based on KWH savings per year as calculated above times power cost:

Electric Energy Cost: \$ 0.0830 per KWH, including demand charges. Results are tabulated on Table 1.

Operations and Maintenance Costs:

Control systems proposed in this project will require preventive maintenance and periodic calibration. It is assumed that this will require a total of about 16 hours per year of additional O&M effort for each system.

16 MH/Yr x \$22/MH x 1.5 (Benefits & OH) \$528 per Year added O&M Cost

Added LCC O&M Cost: 14.74 (UPW Factor) x \$528/Yr = \$ 7,783 Added LCC Costs
per System

Modifications Required:

Raise chilled water temperature to "follow the load": Install a limit switch in each modulating or diversion valve to measure whether the valve is fully open or partially open. Arrange the control circuits so that when all coil control valves are either closed or in a partially open position (indicating light load conditions), the chilled-water temperature supply set point should be raised until one or more coil control valves return to the fully open position. Raise supply air temperature to follow the load. Installation costs are summarized on the attached cost estimate sheet.

Table 1: Chilled Water Reset ECO Calculations

Bldg No.	Savings: KWH/Day	Savings: KWH/Year	Savings: \$/Year	Savings: LCC \$	O&M Cost \$/Year	O&M Cost LCC \$	Investment \$	Total Saved: \$/Year	Total Saved: LCC \$	Payback Period	SIR
Recommended Retrofits											
506 C1	289.00	105,485	\$ 8,755	\$ 136,932	\$ 528	\$ 7,783	\$ 10,101	\$ 8,227	\$ 129,149	1.23	12.79
2105 C1	56.30	20,550	\$ 1,706	\$ 26,676	\$ 528	\$ 7,783	\$ 10,101	\$ 1,178	\$ 18,893	8.58	1.87
2105 C5	56.30	20,550	\$ 1,706	\$ 26,676	\$ 528	\$ 7,783	\$ 10,101	\$ 1,178	\$ 18,893	8.58	1.87
Totals for SIR > 1.0	402	\$ 146,584	\$ 12,166	\$ 190,284	\$ 1,584	\$ 23,348	\$ 30,304	\$ 10,582	\$ 166,935	2.86	5.51

Figure 1: Building 506 Chiller
 220 Ton Trane CVHE-020F-AL-2GB2451DEZA1

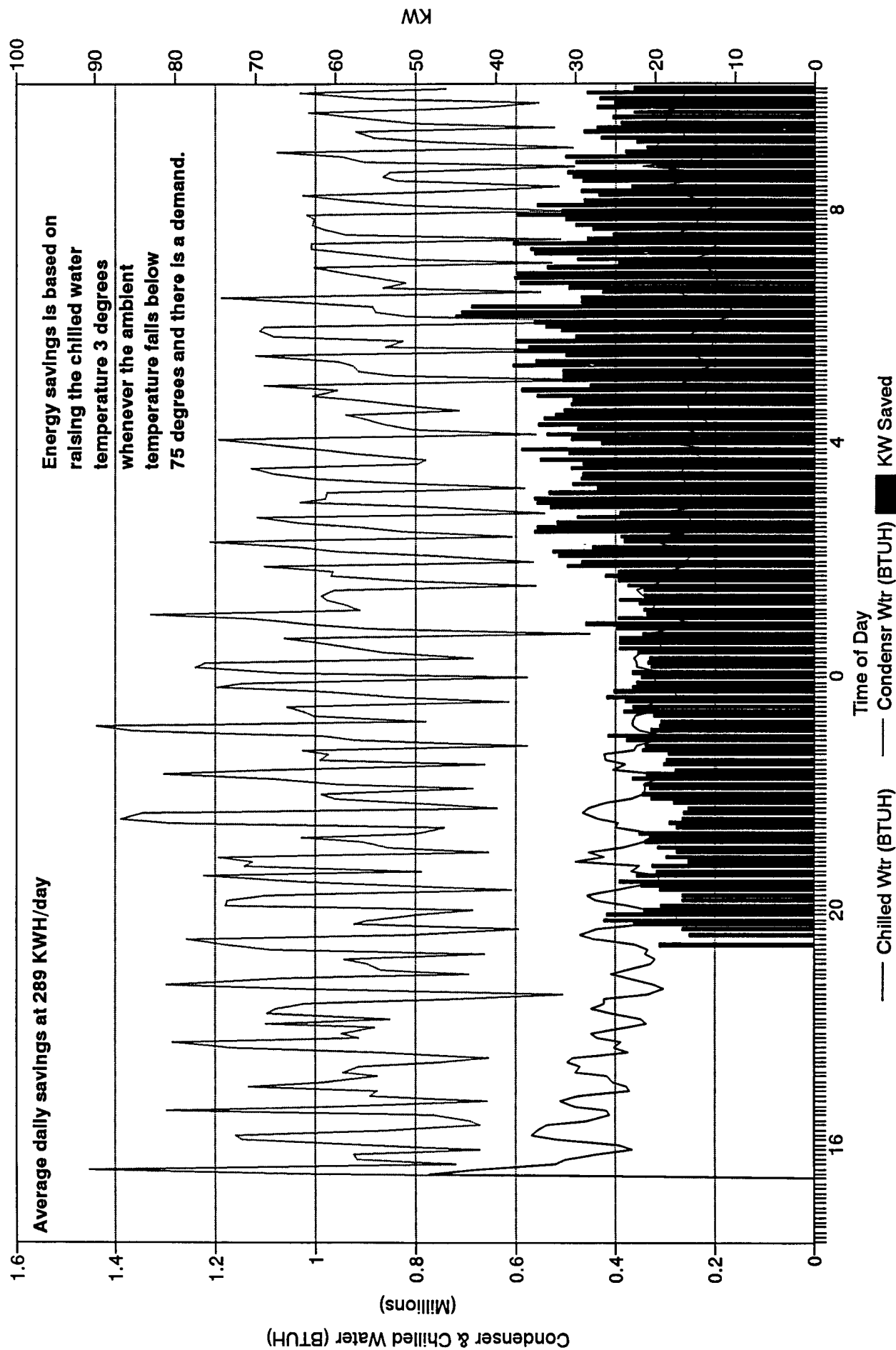


Figure 2: Building 2105 Chiller No. 1
125 Ton Carrier 19DK4629AE

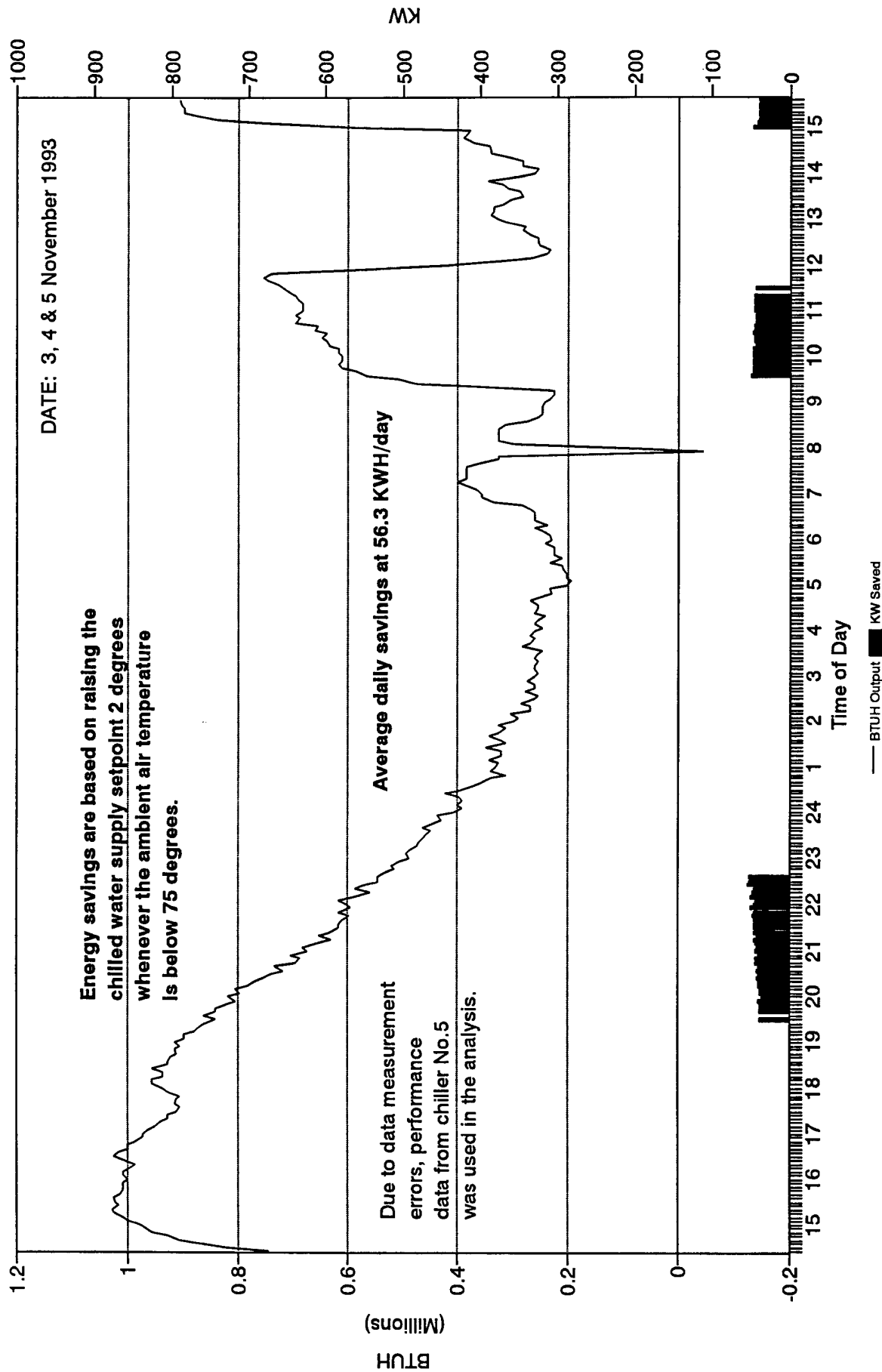
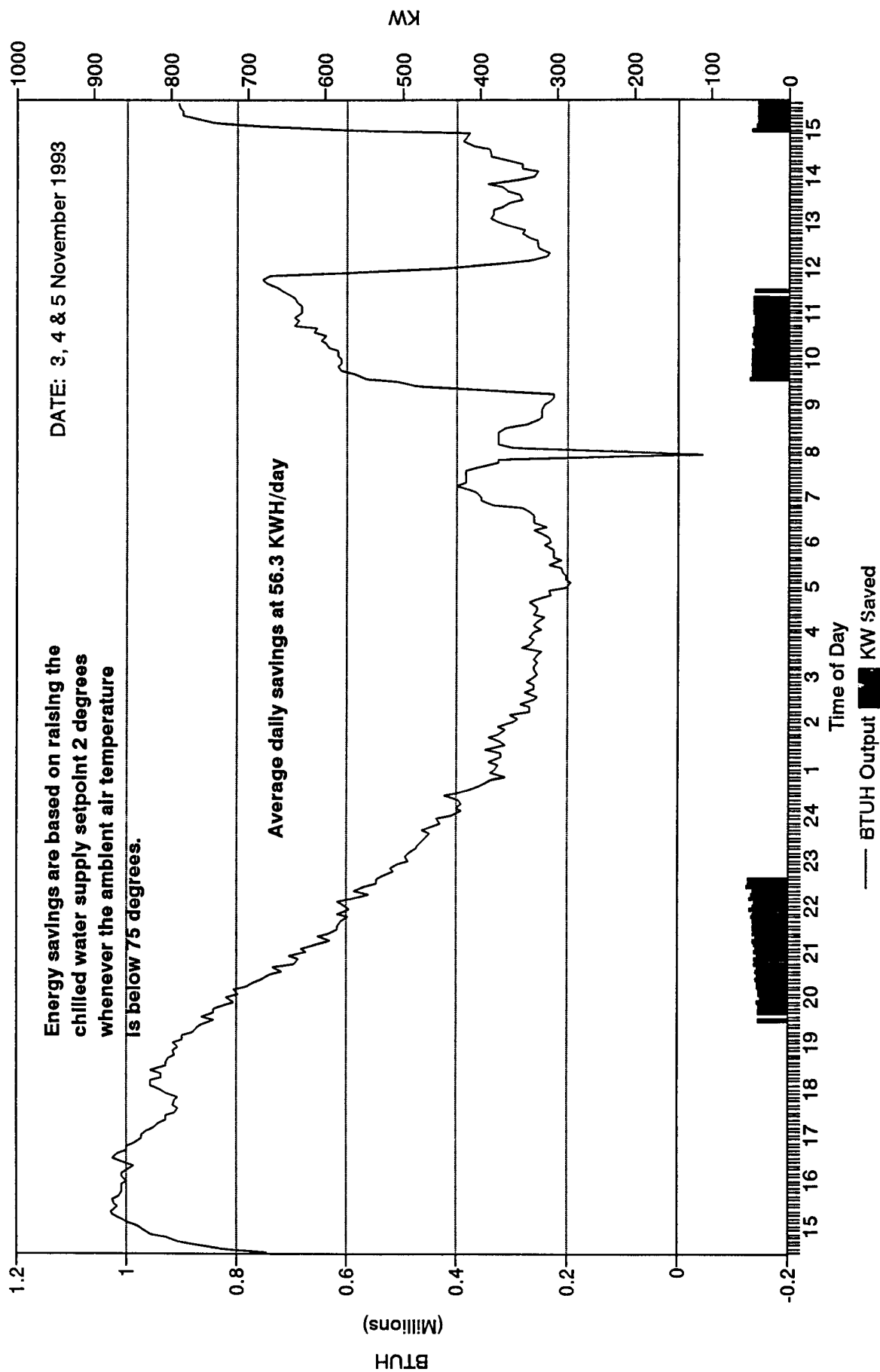


Figure 3: Building 2105 Chiller No. 5
125 Ton Carrier 19DK4629AE



CONSTRUCTION COST ESTIMATE				Date Prepared January 1994		Sheet 1 Of 1	
Project ECIP Facility Energy Improvements				Project No.		Basis for Estimate Code A (no design competed)	
Location Yuma Proving Ground, Arizona							
Engineer-Architect Keller & Gannon							
Drawing No. Chilled Water Reset: Unit Cost Estimate			Estimator R. Bush		Checked By B. Horst		
Line Item	Quantity		Per Unit	Labor Total	Material		Total Cost
	No. Units	Unit Meas.			Per Unit	Total	
Chilled Water Reset Package	1	EA.	\$995	\$995	\$4,976	\$4,976	\$5,971
Package includes temperature sensors, control panel, display panel and field wiring.							
Subtotal				\$995		\$4,976	\$5,971
State Sales Tax	5.5%	%		-		\$274	\$274
Subtotal							\$6,245
Contractor OH & Profit	30.0%	%					\$1,873
Subtotal							\$8,118
Bond	1.0%	%					\$81
Subtotal							\$8,199
Estimating Contingency	10.0%	%					\$820
Total Probable Construction Cost							\$9,019

Life Cycle Cost Analysis Summary Energy Conservation Investment Program (ECIP)

Location: Yuma Proving Ground, Arizona Region No. 4
Project Title: ECIP Facility Energy Improvements -
Replace Glycol Chiller at Building 506
Analysis Date: January 1994 Economic Life: 20 Years

Project No.
Fiscal Year FY96

Preparer: KELLER & GANNON

1. Investment Costs

A. Construction Costs	\$55,898	
B. SIOH	\$ 3,354	
C. Design Cost	\$ 3,354	
D. Total Cost (1A+1B+1C)	\$ 62,606	
E. Salvage Value of Existing Equipment	\$0	
F. Public Utility Company Rebate	\$0	
G. Total Investment (1D-1E-1F)		\$62,606

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost \$/MBTU (1)	Saving MBTU/Year (2)	Annual \$ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	\$24.32	273	\$6,640	15.64	\$103,850
B. Dist			\$0		
C. LPG			\$0		
D. Other			\$0		
E. Demand Savings			\$0		
F. Total		273	\$6,640		\$103,850

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	\$0	
(1) Discount Factor (Table A)	14.74	
(2) Discounted Savings/Cost (3A x 3A1)		\$0

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2 + 3Bd4) \$0

4. First Year Dollar Savings (2F3 + 3A + (3Bd1/Years Economic Life)):	\$6,640	
5. Simple Payback (1G/4):	9.43	Years
6. Total Net Discounted Savings (2F5 + 3C):	\$103,850	
7. Savings to Investment Ratio (SIR) 5/1G:	1.66	

Building 506 - 45 Ton Glycol Chiller Replacement - Detailed Calculations

The Glycol Chiller used for the Ice-On-Coil System is presently rated at a capacity of 45 Tons. The unit was recently converted from a standard chiller rated at 80 Tons capacity; it has been derated for colder-temperature application. Replacement of this converted chiller with one designed for cold temperature application is evaluated.

Based on manufacturer's data, the Ice-On-Coil glycol chiller provides 49.7 tons of refrigeration at 105 °F outside air temperature while drawing 103.9 kW of electric power. Newer chillers designed initially for low temperature operation can provide the same degree of cooling while drawing only 90.2 kW.

Based on daily use of 16 hours per day (20 hours per day are scheduled), year-round, savings are:

$$(103.9 - 90.2) \text{ kW} \times 16 \text{ Hours/Day} \times 365 \text{ Days/Year} = 80,000 \text{ kWh/Year}$$

The incremental cost of electric power is \$0.083 per kWh, thus, annual power cost savings are:

$$(80,000 \text{ kWh/Year} \times \$0.083 = \$6,640 \text{ per year saved})$$

Life cycle energy cost savings are:

$$15.64 \text{ (UPW for electric power, } N=20 \text{ Years)} \times \$6,640 = \$103,850$$

Maintenance costs would be about the same as they are for the existing chiller.

The required investment is about (see attached cost estimate):

$$\$55,898 \times 1.12 \text{ (SIOH \& Design)} = \$62,606$$

The payback period is, thus:

$$\text{Investment} \div \text{Annual Energy Cost Savings} = 9.43 \text{ Years}$$

And the Savings to Investment Ratio (SIR) is:

$$\$103,850 \text{ (Life Cycle Cost Savings)} \div (\text{Investment}) \$62,606 = 1.66$$

CONSTRUCTION COST ESTIMATE					Date Prepared January 1994		Sheet Of 1 1	
Project ECIP Facility Energy Improvements					Project No.		Basis for Estimate Code A (no design competed)	
Location Yuma Proving Ground, Arizona								
Engineer-Architect Keller & Gannon								
Drawing No. Replace Glycol Chiller - Bldg 506				Estimator BIH		Checked By RCL		
Line Item	Quantity		Labor		Material		Total Cost	
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total		
Building 506 Glycol Chiller								
Air Cooled Glycol Chiller	1	EA	\$4,710	\$4,710	\$26,640	\$26,640	\$31,350	
Remove Existing Chiller	1	EA	\$5,888	\$5,888	\$0	\$0	\$5,888	
Subtotal				\$10,598		\$26,640	\$37,238	
State Sales Tax	5.5%	%		-		\$1,465	\$1,465	
Subtotal							\$38,703	
Contractor OH & Profit	30.0%	%					\$11,611	
Subtotal							\$50,314	
Bond	1.0%	%					\$503	
Subtotal							\$50,817	
Estimating Contingency	10.0%	%					\$5,082	
Total Probable Construction Cost							\$55,898	

**Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)**

Location: Yuma Proving Ground, Arizona Region No. 4
Project Title: ECIP Facility Energy Improvements -
Manifold Building 3490 Chillers

Project No.
Fiscal Year FY96

Analysis Date: January 1994 Economic Life: 20 Years

Preparer: KELLER & GANNON

1. Investment Costs

A. Construction Costs	\$51,179	
B. SIOH	\$ 3,071	
C. Design Cost	\$ 3,071	
D. Total Cost (1A + 1B + 1C)	\$ 57,321	
E. Salvage Value of Existing Equipment	\$0	
F. Public Utility Company Rebate	\$0	
G. Total Investment (1D-1E-1F)		\$57,321

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost \$/MBTU (1)	Saving MBTU/Yr(2)	Annual \$ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	\$24.32	316.8	\$7,704	15.64	\$120,498
B. Dist	\$0.00	0.00	\$0.00	17.47	\$0
C. LPG	\$0.00	0.00	\$0.00	19.21	\$0
D. Other					
E. Demand Savings					
F. Total		317	\$7,704		\$120,498

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	(\$1,320)	
(1) Discount Factor (Table A)	14.74	
(2) Discounted Savings/Cost (3A x 3A1)		(\$19,457)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+) Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2 + 3Bd4) (\$19,457)

4. First Year Dollar Savings (2F3 + 3A + (3Bd1/Years Economic Life)):	\$6,384	
5. Simple Payback (1G/4):	8.98	Years
6. Total Net Discounted Savings (2F5 + 3C):	\$101,041	
7. Savings to Investment Ratio (SIR) 5/1G:	1.76	

Manifold Building 3490 Chillers - Detailed Calculations

Building 3490, Test Evaluation Facility, is provided space cooling by three (3) air cooled chillers serving air handling units. Each of the chillers serve different parts of the building. During low load periods all three chiller systems operate near their minimum efficiencies with significant unloading.

Installation of piping and controls to combine the three systems into a single system will allow low load conditions to be served by only one or two compressors operating near their rated capacities. Energy savings will result because compressors operate more efficiently at rated capacities than in unloaded conditions.

Replacing the rooftop cooling unit serving the Electronics Room in the Gun Shop with a chilled water fan coil unit will save additional energy.

Energy Saving Calculations:

Data collected for about a 24 hour period in October 1993:

- Cooling load measurements - BTUH of chilled water from each chiller
- kW Power consumption measurements - for each chiller
- Outside dry-bulb air temperature measurements
- Manufacture's data on chillers and compressors

Assumptions:

1. Chillers operate at peak capacity during hottest observed temperatures in TM 5-785 Bin data.
2. For peak temperature operations, chiller performance data at 105 °F dry-bulb applies.
3. Measured performance data (power use and thermal load) applies to measured outdoor temperatures.

Existing System Annual Power Usage Estimate

Chillers are manufactured by Webster, now out of business. Available catalog data lists the following for 105°F and 45°F LWT; Copeland compressor data for 50% loading:

Chiller	Model	Unloading	Tons	kW	100% EER	50% EER
Chiller 1	CPK-26A	100, 50, 0	17.6	21.3	9.92	9.23
Chiller 2	CPK-51A	100,75,50,25,0	35.1	42.1	10.00	9.31
Chiller 3	CPK-100A2	100,75,50,25,0	66.5	93.1	8.57	7.98

Chillers are loaded as shown on Figures 1 and 2. Existing energy usage is determined based on measurements:

Measurement period power usage by Chillers 1, 2 and 3:	860	kWH
Measurement period Cooling Degree-Hours:	252	Degree-Hours
Annual Cooling Degree-Hours from TM 5-785 Bin Data:	109,474	Degree-Hours

Estimated annual power use of existing Chillers 1, 2 & 3:

Measurement Period kWH x Annual Deg-Hours ÷ Measurement Period Deg-Hours = **373,923 kWH/Year**

Estimated annual power usage of Electronics Room Rooftop type cooling unit:

Unit size, about 5 Tons, energized continuously = **43,800 kWH/Year**

Proposed System Annual Power Usage Estimate

The proposed system of manifolding chillers will provide for operations usually near one of the chiller's full load operating point, thus, more efficiently. Based on manufacturer data for full load operation at each of the temperature bins, future energy consumption is estimated at:

Outside

Air Temp °F	Total Chiller kW	Bin Hours /Year	Cooling kWH/Yr	Remarks
105	158.9	282	44,810	Maximum load, all chillers at 100%
100	133.1	398	52,954	Chiller 1 off, Chillers 2 & 3 at 100%
95	110.5	512	56,576	Chiller 2 off, Chillers 1 & 3 at 100%
90	65.9	641	42,258	Chillers 1 & 2 off, Chiller 3 on 75%
85	53.8	845	45,419	Chillers 2 off, Chillers 1 & 3 at 50%.
80	41.9	829	34,735	Chillers 1 & 3 off, Chiller 2 at 100%.
75	30.1	761	22,887	Chillers 1 & 3 off, Chiller 2 at 75%
70	21.2	784	16,621	Chillers 2 & 3 off, Chiller 1 at 100%
65	10.6	815	8,639	Chillers 2 & 3 off, Chiller 1 at 50%
60	0.0	802	-	
Total			324,898	kWh/Year

Savings from replacing Gun Shop Electronics Room Rooftop type Cooling Unit:

43,800 kWh/Year

Total Savings = 92,825 kWh/Year \$ 0.083 /kWH = \$ 7,704 /Year

Operations & Maintenance Costs:

Manifolding of chillers involves installation of controls, piping and fittings, including control valves. Annual O&M labor to maintain these additional building components is estimated to require about 40 MH. Assuming a labor rate of \$22 per hour, plus 50% for overhead and fringe benefits, additional yearly O&M cost is:

$$40 \text{ MH} \times \$22 / \text{MH} \times 1.5 = \$ 1,320 \text{ per year added O\&M cost}$$

Economic Evaluation Results:

This option was found cost effective with a payback period of about 9 years, and a savings to investment ratio of 1.76.

CONSTRUCTION COST ESTIMATE					Date Prepared January 1994		Sheet 1 of 1	
Project ECIP Facility Energy Improvements					Project No.		Basis for Estimate Code A (no design completed)	
Location Yuma Proving Ground, Arizona Bldg 3490								
Engineer-Architect Keller & Gannon								
Drawing No. Manifold Chillers				Estimator R. Bush		Checked By B. Horst		
Line Item	Quantity		Labor		Material		Total Cost	
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total		
2" Steel Pipe	600	Ft	\$9.35	\$5,610	\$5.73	\$3,438	\$9,048	
6" Steel Pipe	300	Ft	\$25.71	\$7,713	\$25.62	\$7,686	\$15,399	
Pipe Fittings	1	Job	\$800	\$800	\$800	\$800	\$1,600	
Relocate Chiller #1	1	Ea	\$4,000	\$4,000		\$0	\$4,000	
Demolish & Relocate Pipe	1	Job	\$3,000	\$3,000		\$0	\$3,000	
5 Ton Chilled Water Fan-Coil Unit	1	Ea	\$150	\$150	\$1,500	\$1,500	\$1,650	
Subtotal				\$21,273		\$13,424	\$34,697	
State Sales Tax	5.5%	%		-		\$738	\$738	
Subtotal							\$35,435	
Contractor OH & Profit	30.0%	%					\$10,631	
Subtotal							\$46,066	
Bond	1.0%	%					\$461	
Subtotal							\$46,527	
Estimating Contingency	10.0%	%					\$4,653	
Total Probable Construction Cost							\$51,179	

Life Cycle Cost Analysis Summary

Energy Conservation Investment Program (ECIP)

Location: Yuma Proving Ground, Arizona Region No. 4
 Project Title: ECIP Faculty Energy Improvements -
 Install Duty Cycling Controls at Buildings 451 & 3490
 Analysis Date: January 1994 Economic Life: 20 YEARS

Project No.
 Fiscal Year FY96

Preparer: KELLER & GANNON

1. Investment Costs

A. Construction Costs	\$5,825	
B. SIOH	\$349	
C. Design Cost	\$349	
D. Total Cost (1A+1B+1C)	\$6,524	
E. Salvage Value of Existing Equipment	\$0	
F. Public Utility Company Rebate	\$0	
G. Total Investment (1D-1E-1F)		\$6,524

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost \$/MBTU/(1)	Saving MBTU/YR(2)	Annual \$ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	\$24.319	0.0	\$0	15.64	\$0
B. Dist					
C. Propane					
D. Other					
E. Demand Savings	\$31.68/kW	36.8 kW	\$1,164	15.64	\$18,210
F. Total	Based on \$1.98/kW/Mo @ 6 Months + 10 times rate for 1 Mo.		\$1,164		\$18,210

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	(\$132)	
(1) Discount Factor (Table A)	14.74	
(2) Discounted Savings/Cost (3A x 3A1)		(\$1,946)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) (\$1,946)

4. First Year Dollar Savings (2F3 + 3A + (3Bd1/Years Economic Life)):	\$1,032	
5. Simple Payback (1G/4):	6.32	Years
6. Total Net Discounted Savings (2F5 + 3C):	\$16,265	
7. Savings to Investment Ratio (SIR) 5/1G:	2.49	

Duty Cycling Controls - Detailed Calculations

Installing a programmable controller to turn off the chillers 10 minutes per hour during peak electrical demand periods will save demand and penalty charges by the Western Area Power Authority (WAPA). Yuma Proving Ground is charged \$1.98 per kW-Month. This is a very low demand charge compared to commercially available power supplies, however, a penalty of 10 times this rate is charged whenever power demand exceeds YPG's allocation. The allocation is presently exceeded several times per year. Energy cost savings, thus, assume one excursion per year.

All chiller systems surveyed were considered; only two buildings' chiller systems are included: building 451, the Cactus Club and building 3490, the Test Evaluation Facility.

Building 506, the Enlisted Persons Barracks, is excluded from this project because its chiller system is already fitted with an electrical demand limiting system: the Ice-On-Coil system. The Ice-On-Coil system operates in recovery mode (cooling from stored ice) during the peak electrical demand period; no compressors are normally operated during these periods.

Building 2105, the Range Operations Center is not included because it houses critical mission operations consisting of extensive computer systems. Additionally, the building cooling system is served by a solar-assisted absorption cooling system which is operated during the peak demand periods.

Building 3482, the Test Preparation Facility, is an explosives assembly building and must have uninterrupted air conditioning services for safety reasons. Building 3510 is an Explosives Storage Magazine and must have uninterrupted air conditioning service for the same reason. These buildings are not included in the duty cycling control project.

Calculations result in a combined SIR of 2.49. The retrofit is recommended for installation to allow future connection to a basewide EMCS; all building chillers not servicing critical mission requirements will have to be connected to such a load shedding system.

Energy Savings Calculation:

This project is designed to reduce charges for electrical demand during peak cost periods. No energy savings are achieved by turning chillers off for short periods, since system controls will force the chillers to "make-up" the load when they are operating. The chiller's connected load is divided by "6" to determine demand kW reduction. Calculations are provided on Table 1. The cost savings basis is addressed on Table 1.

Operations & Maintenance Costs:

It is assumed that O&M on each new control system will require 2 hours of maintenance annually. A labor rate of \$22 per hour, plus 50% overhead and fringe benefits is assumed.

TABLE 1: SUMMARY OF CHILLER DUTY CYCLING CONTROLS RETROFIT CALCULATIONS

Bldg Unit No. Description	Capacity (Tons)	Manufacturer	Refrigerant	Chiller Load kW	Source/Reason	Energy Savings kW	\$/Year	LCC \$	O&M Savings \$/Year	LCC \$	Total Savings \$/Year	LCC \$	Controls Investment	Econ Measures SIR	Payback
451 A/C Reciprocating	55	Carrier	R-22, 136 lbs.	64.02	Catalog	10.7	\$338	\$5,287	(\$66)	(\$973)	\$272	\$4,314	\$2,554	1.69	9.39
506 W/C Centrifugal	220	Trane	R-11, 450 lbs.	NA	Bldg has demand	-	-	-	-	-	-	-	-	-	-
506 A/C Recip. - Glycol (1)	36	Trane	R-22 (Rebuilt)	NA	limiting system	-	-	-	-	-	-	-	-	-	-
2105 C-1 W/C Centrifugal	125	Trane	R-113, 415 lbs.	NA	Bldg houses	-	-	-	-	-	-	-	-	-	-
2105 C-2 W/C Reciprocating	40	Trane	R-22, 55 lbs.	NA	critical mission	-	-	-	-	-	-	-	-	-	-
2105 C-5 W/C Centrifugal	125	Carrier	R-11	NA	activities	-	-	-	-	-	-	-	-	-	-
3482 W/C Reciprocating - DX	62	Carrier	R-22	NA	Safety	-	-	-	-	-	-	-	-	-	-
3490 C-1 A/C Reciprocating	25	Webster	R-22	21.3	Catalog	3.6	-	-	-	-	-	-	-	-	-
3490 C-2 A/C Reciprocating	50	Webster	R-22	42.1	Catalog	7.0	\$826	\$12,924	(\$66)	(\$973)	\$760	\$11,951	\$3,970	3.01	5.22
3490 C-3 A/C Reciprocating	100	Webster	R-22	93.1	Catalog	15.5	-	-	-	-	-	-	-	-	-
3510 W/C Reciprocating - DX	40	Trane	HFC-134a (Note 2)	NA	Safety	-	-	-	-	-	-	-	-	-	-
Totals						36.8	\$1,164	\$18,210	(\$132)	(\$1,946)	\$1,032	\$16,266	\$6,624	2.49	6.32
A/C Air Cooled															
W/C Water Cooled															
DX Direct Expansion Unit															

Additional O&M costs assume 2 hours maintenance per year at \$22/MH x 1.5 for OH & fringes

Demand charge savings are based on WAPA demand charge of \$1.96/kW-Mo and a penalty equal to 10 times this rate (usually experienced once or twice a year). Cost savings based on avoiding a single such occurrence each year.

CONSTRUCTION COST ESTIMATE					Date Prepared January 1994		Sheet 1 Of 1	
Project ECIP Facility Energy Improvements					Project No.		Basis for Estimate Code A (no design competed)	
Location Yuma Proving Ground, Arizona								
Engineer-Architect Keller & Gannon								
Drawing No. Duty Cycling Controls				Estimator BIH		Checked By RCL		
Line Item	Quantity		Labor		Material		Total Cost	
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total		
Building 451 (1 Chiller)								
Programable Controller	1	EA	\$350	\$350	\$750	\$750	\$1,100	
Digital Output Point W/Wiring	1	EA	\$100	\$100	\$320	\$320	\$420	
Subtotal				\$450		\$1,070	\$1,520	
State Sales Tax	5.5%	%		-		\$59	\$59	
Subtotal							\$1,579	
Contractor OH & Profit	30.0%	%					\$474	
Subtotal							\$2,053	
Bond	1.0%	%					\$21	
Subtotal							\$2,073	
Estimating Contingency	10.0%	%					\$207	
Total Probable Construction Cost							\$2,280	
Building 3490 (3 Chillers)								
Programable Controller	1	EA	\$350	\$350	\$750	\$750	\$1,100	
Digital Output Point W/Wiring	3	EA	\$100	\$300	\$320	\$960	\$1,260	
Subtotal				\$650		\$1,710	\$2,360	
State Sales Tax	5.5%	%		-		\$94	\$94	
Subtotal							\$2,454	
Contractor OH & Profit	30.0%	%					\$736	
Subtotal							\$3,190	
Bond	1.0%	%					\$32	
Subtotal							\$3,222	
Estimating Contingency	10.0%	%					\$322	
Total Probable Construction Cost							\$3,544	

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)

Location: Yuma Proving Ground, Arizona
 Project Title: ECIP Facility Energy Improvements
 Retrofit Lighting Fixtures

Region No. 4

Project No.
 Fiscal Year FY96

Analysis Date: January 1994 Economic Life: 15 YEARS

Preparer: KELLER & GANNON

1. Investment Costs

A. Construction Costs	\$256,449	
B. SIOH	\$15,387	
C. Design Cost	\$15,387	
D. Total Cost (1A+1B+1C)	\$287,223	
E. Salvage Value of Existing Equipment	\$0	
F. Public Utility Company Rebate	\$1,206	
G. Total Investment (1D-1E-1F)		\$286,017

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost \$/MBTU(1)	Saving MBTU/YR(2)	Annual \$ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	\$24.32	1,657.3	\$40,303	12.49	\$503,390
B. Dist					
C. Propane					
D. Other					
E. Demand Savings				12.49	\$0
F. Total		1,657.3	\$40,303		\$503,390

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	\$12,796	
(1) Discount Factor (Table A)	11.85	
(2) Discounted Savings/Cost (3A x 3A1)		\$151,628

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) \$151,628

4. First Year Dollar Savings (2F3 + 3A + (3Bd1/Years Economic Life)):	\$53,099	
5. Simple Payback (1G/4):	5.39	Years
6. Total Net Discounted Savings (2F5 + 3C):	\$655,018	
7. Savings to Investment Ratio (SIR) 5/1G:	2.29	

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)

Location:	Yuma Proving Ground, Arizona	Region No. 4	Project No.
Project Title:	ECIP Facility Energy Improvements		Fiscal Year FY96
	Install Occupancy Sensor Switching		
Analysis Date: January 1994	Economic Life: 15 YEARS		Preparer: KELLER & GANNON

1. Investment Costs

A. Construction Costs	\$46,121		
B. SIOH	\$2,767		
C. Design Cost	\$2,767		
D. Total Cost (1A+1B+1C)	\$51,655		
E. Salvage Value of Existing Equipment		\$0	
F. Public Utility Company Rebate		\$0	
G. Total Investment (1D-1E-1F)			\$51,655

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost \$/MBTU/(1)	Saving MBTU/YR(2)	Annual \$ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	\$24.32	469.2	\$11,410	12.49	\$142,512
B. Dist					
C. Propane					
D. Other					
E. Demand Savings				12.49	\$0
F. Total		469.2	\$11,410		\$142,512

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	\$0		
(1) Discount Factor (Table A)		11.85	
(2) Discounted Savings/Cost (3A x 3A1)			\$0

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) \$0

4. First Year Dollar Savings (2F3 + 3A + (3Bd1/Years Economic Life)):	\$11,410	
5. Simple Payback (1G/4):	4.53	Years
6. Total Net Discounted Savings (2F5 + 3C):	\$142,512	
7. Savings to Investment Ratio (SIR) 5/1G:	2.76	

Life Cycle Cost Analysis Summary Energy Conservation Investment Program (ECIP)

Location:	Yuma Proving Ground, Arizona	Region No. 4	Project No.
Project Title:	ECIP Facility Energy Improvements		Fiscal Year FY96
	Install Light Fixture Switching		
Analysis Date: January 1994	Economic Life: 15 YEARS		Preparer: KELLER & GANNON

1. Investment Costs

A. Construction Costs	\$13,589	
B. SIOH	\$815	
C. Design Cost	\$815	
D. Total Cost (1A+1B+1C)	\$15,220	
E. Salvage Value of Existing Equipment	\$0	
F. Public Utility Company Rebate	\$0	
G. Total Investment (1D-1E-1F)		\$15,220

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost \$/MBTU/(1)	Saving MBTU/YR(2)	Annual \$ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	\$24.32	104.7	\$2,546	12.49	\$31,805
B. Dist					
C. Propane					
D. Other					
E. Demand Savings				12.49	\$0
F. Total		104.7	\$2,546		\$31,805

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	\$0	
(1) Discount Factor (Table A)	11.85	
(2) Discounted Savings/Cost (3A x 3A1)		\$0

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) \$0

4. First Year Dollar Savings (2F3 + 3A + (3Bd1/Years Economic Life)):	\$2,546	
5. Simple Payback (1G/4):	5.98	Years
6. Total Net Discounted Savings (2F5 + 3C):	\$31,805	
7. Savings to Investment Ratio (SIR) 5/1G:	2.09	

Retrofit Lighting Fixtures, Install Occupancy Sensors, and Install Light Fixture Switching — Detailed Calculations

Lighting and Control Retrofits Evaluated			
Project	Description	Type	Unit Cost (\$)
A	1-Lamp Electronic Ballast & T8 Lamp Retrofit	Fixture	76.70
B	2-Lamp Electronic Ballast & T8 Lamps Retrofit	Fixture	83.55
C	3-Lamp Electronic Ballast & T8 Lamps Retrofit	Fixture	100.77
D	4-Lamp Electronic Ballast & T8 Lamps Retrofit	Fixture	167.10
F	New Fixture: 2-Lamp Electronic Ballast & T8 Lamps	Fixture	331.47
H	3-Lamp Electronic Ballast & T8 Lamps & Specular Reflector Retrofit	Fixture	152.69
I	Occupancy Sensor Lighting Control — Ceiling Mounted	Control	298.55
J	Occupancy Sensor Lighting Control — Automatic Wall Switch	Control	130.18
K	New Fixture: 2-Lamp Compact Fluorescent, 2 x 13W/5T4	Fixture	153.99
L	New Fixture: 2-Lamp Electronic Ballast & T8 Lamps, 2' Surface Mount	Fixture	373.00
M	Install Switching for Assembly Rooms — Building 3482 (Total cost shown)	Control	13,589.19

Fixture Retrofit Evaluations

Both lighting fixture modifications and replacements are considered. Most existing fluorescent fixtures use 40 watt T12 lamps and standard ballasts. (Some energy saving 34 watt lamps and energy saving ballasts are installed, but they do not predominate.)

Retrofits A, B, C and D are one-for-one lamp and ballast replacements for existing fixtures. Retrofitting existing one-lamp fluorescent fixtures with electronic ballasts and 32 watt T8 lamps will reduce fixture input power by over 20 watts in standard core and coil ballasts.

Retrofit H includes the same type of ballast and lamp replacements as above and, in addition, requires installation of a specular reflector in the fixture. This allows 4-lamp fixtures to be converted to 3-lamp fixtures without reducing illumination levels.

New fluorescent fixtures are proposed to replace existing incandescent fixtures. Retrofit types F and L are developed for this purpose.

Energy savings and economic analysis calculations for either a fixture modification or replacement are the same:

Lighting Retrofit Evaluation Calculations

Label	Contents / Calculation Explanation
RET_TYP	Retrofit type (See schedule above)
KW_SVD	$(E_KW) - (S_KW) =$ Demand savings (kW) from lighting retrofit (See note below)
KWH_SV	$(E_KWH/Y - S_KWH/Y) + [S\#FXTR * SHR/WK * 52 * (EW/LAMP + EBAL_W - SW/LAMP - SBAL_W)/100000] =$ = Electric savings from retrofit, including cooling energy savings based on EER of 10.0
PWR_\$Y	$KWH_SVD * \$0.083 =$ Annual electric power cost savings (Average YPG power cost)
PWR_LCC\$	$PWR_$/Y * 12.49 =$ Life cycle savings, Life of 15 years; UPV factor 3.1% discount rate
CONST\$	$@VLOOKUP(RET_TYP,RET_TABLE,2) =$ Construction cost from retrofit types schedule
SIOH	$CONST$ * 0.120 =$ SIOH and design at 6% each of construction cost
REBATE	$(-\$8.15 * KW_SVD) =$ Arizona Public Services rebate for lighting retrofit kW (demand) savings for partial requirements
INVEST	$@SUM(CONST$,SIOH,REBATE) =$ Total investment per ECIP guidance
O&M_\$Y	$[@VLOOKUP(EL_TYPE,OLD,4) * EHR/WK * EL/FXTR * E\#FXTR] - [@VLOOKUP(SL_TYPE,NEW,4) * SHR/WK * SL/FXTR * S\#FXTR] =$ = Annual O&M savings (additional cost) for lamp replacements; refer to schedules OLD" and "NEW"
O&M_LC	$(O\&M_$/Y * 11.85) =$ Life cycle O&M cost for Life of 15 years; UPV factor 3.1% discount rate
TOT_\$Y	$(O\&M_$/Y + PWR_$/Y) =$ Total annual cost savings
TOT_LCC\$	$(O\&M_LCC$ + PWR_LCC$) =$ Total life cycle cost savings
SIR	$(TOT_LCC$) / (INVEST) =$ Savings-to-investment ratio
PAYBCK	$(INVEST) / (TOT_$/Y) =$ Payback period (years)
Notes: Parameters shown above for existing and retrofit (savings) cases are indicated by prefixes: "E_" and "S_", respectively, corresponding to labels used above to explain lighting energy use calculations. RET_TABLE refers to unit costs of various retrofits as summarized above. OLD and NEW refer to relamping costs as are summarized below.	

Electric energy savings of proposed retrofits includes consideration of reduced space cooling demand due to lower heat rejection rates of lighting fixtures after modification. Electric power savings due to reduced cooling loads are, thus:

$$[(\text{Existing Fixture Watts}) - (\text{Retrofit Fixture Watts})] * 3.413 = \text{BTUH cooling load reduction}$$

Applying an EER of 10.0 (a fairly conservative value based on field measurements), energy savings due to reduced cooling energy requirements are:

$$[\text{BTUH Load Reduction}] / (10.0 * 1,000 \text{ W/kW}) * (\text{Operating Hrs/Yr}) = \text{kWH/Year saved}$$

Relamping Costs for Existing Fixtures (OLD)

Fixture Type	Life (Hours)	Lamp Cost (\$)	Hours per Lamp Change	Cost per Lamp-Hr (\$)
Fluorescent	20,000	1.59	0.167	0.0170
Incandescent	750	1.75	0.083	0.2929

Relamping Costs for Retrofit Fixtures (NEW)

Retrofit Type	Life (Hours)	Lamp Cost (\$)	Hours Per Lamp Change	Cost per Lamp-Hr (\$)
A	20,000	4.50	0.167	0.0246
B	20,000	4.50	0.167	0.0246
C	20,000	4.50	0.167	0.0246
D	20,000	4.50	0.167	0.0246
F	20,000	4.50	0.167	0.0246
H	20,000	4.50	0.167	0.0246
K	10,000	10.00	0.083	0.0649
L	20,000	6.20	0.167	0.1036
Hours per lamp change: F = 10 minutes; I = 5 minutes				
Cost/lamp-hour: (lamp cost + hrs per lamp change * \$29.69/MH / lamp life * 52)				

Controls Retrofits

Lighting control retrofits evaluated involve installing occupancy sensor switching in offices, conference rooms, bathrooms and other areas where lights are normally turned on for periods when no one is present. Two types of occupancy sensors are considered. A wall switch type sensor is the least expensive and simply replaces a small office's toggle switch. For larger offices and open areas, ceiling mounted sensors are evaluated. Ceiling mounted switches are more expensive since a relay and additional wiring are required.

Energy savings of at least 25% have been achieved in many similar retrofits according to Arizona Public Service Company. This savings level is assumed for these evaluations.

Energy and cost savings are determined using the same formulae as are shown above for lighting energy use calculations. The operating hours per week are simply factored down.

The following table summarizes the results of economic evaluations for lighting fixture and control retrofits.

SUMMARY OF BUILDING LIGHTING AND CONTROLS RETROFIT EVALUATIONS

Building Number	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/yr)	Power \$ Saved (\$/Yr)	Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC \$ Saved	Total Cost Savings \$/Yr	SIR	Pay-back
Lighting Retrofits Recommended														
Building 451	68	H	2.65	11,078	\$919	\$11,484	\$5,681	(\$32)	\$6,332	(\$82)	(\$971)	\$838	\$10,513	1.66
Building 451	11	B	0.86	3,675	\$305	\$3,810	\$1,680	(\$11)	\$1,870	(\$26)	(\$313)	\$279	\$3,497	1.87
Building 451	35	K	1.49	6,009	\$565	\$7,059	\$5,740	(\$9)	\$6,420	\$468	\$5,548	\$1,033	\$12,607	1.96
Building 506A	80	A	1.73	12,293	\$1,020	\$12,744	\$6,136	(\$15)	\$6,858	(\$92)	(\$1,084)	\$929	\$11,659	1.70
Building 506A	151	B	5.91	17,899	\$1,486	\$18,555	\$12,616	(\$32)	\$14,132	(\$164)	(\$1,948)	\$1,321	\$16,607	1.18
Building 506A	1	D	0.08	273	\$23	\$283	\$167	(\$1)	\$186	(\$3)	(\$30)	\$20	\$252	1.36
Building 506A	39	K	2.65	9,267	\$769	\$9,607	\$6,396	(\$10)	\$7,153	\$534	\$6,333	\$1,304	\$15,940	2.23
Building 506B	2	H	0.21	611	\$51	\$634	\$305	(\$2)	\$340	(\$1)	(\$6)	\$50	\$626	1.84
Building 506B	87	L	15.49	51,587	\$4,282	\$53,479	\$32,451	(\$87)	\$36,279	\$8,138	\$96,432	\$12,419	\$149,911	4.13
Building 506B	107	B	4.61	30,638	\$2,543	\$31,762	\$8,940	(\$37)	\$9,980	(\$110)	(\$1,307)	\$2,433	\$30,454	3.05
Building 506B	89	F	10.47	35,226	\$2,924	\$36,518	\$29,169	(\$88)	\$32,560	\$6,132	\$72,660	\$9,056	\$109,178	3.35
Building 506C	28	B	1.09	3,957	\$328	\$4,102	\$2,339	(\$13)	\$2,607	(\$36)	(\$422)	\$293	\$3,680	1.41
Building 506C	28	D	2.18	7,595	\$630	\$7,874	\$4,679	(\$28)	\$5,212	(\$69)	(\$819)	\$561	\$7,054	1.35
Building 2105 1st Flr N	115	B	4.49	23,706	\$1,968	\$24,575	\$9,608	(\$55)	\$10,706	(\$174)	(\$2,060)	\$1,794	\$22,515	2.10
Building 2105 1st Flr N	208	C	11.44	47,376	\$3,932	\$49,113	\$20,960	(\$160)	\$23,317	(\$386)	(\$4,570)	\$2,303	\$28,782	2.49
Building 2105 1st Flr N	68	H	7.14	28,118	\$2,334	\$29,149	\$10,383	(\$54)	\$11,574	(\$31)	(\$367)	\$2,303	\$28,782	2.49
Building 2105 1st Flr S	12	A	0.23	1,601	\$133	\$1,659	\$920	(\$5)	\$1,027	(\$12)	(\$145)	\$121	\$1,514	1.47
Building 2105 1st Flr S	190	B	7.41	31,014	\$2,574	\$32,151	\$15,875	(\$89)	\$17,690	(\$242)	(\$2,869)	\$2,332	\$29,282	1.66
Building 2105 1st Flr S	120	C	6.60	24,351	\$2,021	\$25,244	\$12,092	(\$96)	\$13,450	(\$212)	(\$2,518)	\$1,809	\$22,727	1.69
Building 2105 1st Flr S	54	H	5.67	20,027	\$1,662	\$20,762	\$8,245	(\$45)	\$9,189	(\$23)	(\$271)	\$1,639	\$20,490	2.23
Building 2105 2nd Flr S	461	B	17.98	75,957	\$6,304	\$78,742	\$38,517	(\$208)	\$42,936	(\$591)	(\$7,009)	\$5,713	\$71,733	1.67
Building 2105 2nd Flr S	28	H	2.94	9,566	\$794	\$9,917	\$4,275	(\$21)	\$4,767	(\$11)	(\$127)	\$783	\$9,790	2.05
Building 3490	157	B	6.12	18,966	\$1,574	\$19,661	\$13,117	(\$76)	\$14,617	(\$190)	(\$2,252)	\$1,384	\$17,409	1.19
Building 3490	2	C	0.11	366	\$30	\$380	\$202	(\$2)	\$224	(\$4)	(\$43)	\$27	\$336	1.50
Building 3490	39	H	4.10	13,628	\$1,131	\$14,128	\$5,955	(\$30)	\$6,639	(\$18)	(\$211)	\$1,113	\$13,917	2.10
Subtotal for SIR > 1.0	2,180		123.64	485,584	\$40,303	\$503,390	\$286,449	(\$1,206)	\$286,065	\$12,796	\$151,628	\$63,099	\$655,018	2.29

Lighting Sensor-Controls Retrofits Recommended

Building 451	8	J	0.00	3,875	\$322	\$4,017	\$1,041	\$0	\$1,166	\$0	\$0	\$322	\$4,017	3.44
Building 506A Offices	1	I	0.00	943	\$78	\$978	\$299	\$0	\$334	\$0	\$0	\$78	\$978	2.93
Building 506B Corridors	21	I	0.00	8,926	\$741	\$9,253	\$6,270	\$0	\$7,022	\$0	\$0	\$741	\$9,253	1.32
Building 506B Offices	2	I	0.00	1,303	\$108	\$1,351	\$597	\$0	\$669	\$0	\$0	\$108	\$1,351	2.02
Building 2105 1st Flr N	17	I	0.00	18,352	\$1,523	\$19,025	\$5,075	\$0	\$5,684	\$0	\$0	\$1,523	\$19,025	3.35
Building 2105 1st Flr N	29	J	0.00	14,540	\$1,207	\$15,073	\$3,775	\$0	\$4,228	\$0	\$0	\$1,207	\$15,073	3.56
Building 2105 1st Flr S	14	I	0.00	18,315	\$1,520	\$18,986	\$4,180	\$0	\$4,681	\$0	\$0	\$1,520	\$18,986	4.06
Building 2105 1st Flr S	46	J	0.00	13,619	\$1,130	\$14,118	\$5,988	\$0	\$6,707	\$0	\$0	\$1,130	\$14,118	2.11
Building 2105 2nd Flr S	32	I	0.00	25,345	\$2,104	\$26,274	\$9,554	\$0	\$10,700	\$0	\$0	\$2,104	\$26,274	2.46
Building 2105 2nd Flr S	45	J	0.00	26,125	\$2,168	\$27,083	\$5,858	\$0	\$6,561	\$0	\$0	\$2,168	\$27,083	4.13
Building 3490	6	I	0.00	2,879	\$239	\$2,984	\$1,791	\$0	\$2,006	\$0	\$0	\$239	\$2,984	1.49
Building 3490	13	J	0.00	3,249	\$270	\$3,368	\$1,692	\$0	\$1,895	\$0	\$0	\$270	\$3,368	1.78
Subtotal for SIR > 1.0	234	I&J	0.00	137,471	\$11,410	\$142,512	\$46,121	\$0	\$51,655	\$0	\$0	\$11,402	\$142,512	2.76

Lighting Switching-Controls Retrofits Recommended

Building 3482	19	M	0.00	30,680	\$2,546	\$31,805	\$13,589	\$0	\$15,220	\$0	\$0	\$2,546	\$31,805	2.09
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Total Recommended

Lighting & Control Retrofits	123.64	653,735	\$64,260	\$677,707	\$316,168	\$37,839	(\$1,206)	\$352,940	\$12,796	\$161,628	\$67,048	\$829,335	2.35
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CONSTRUCTION COST ESTIMATE					Date Prepared January 1994		Sheet Of 1 4	
Project ECIP Facility Energy Improvement				Project No.		Basis for Estimate Code A (no design competed)		
Location Yuma Proving Ground, Arizona								
Engineer-Architect Keller & Gannon								
Drawing No.			Estimator BIH			Checked By RCL		
Line Item	Quantity		Labor *		Material		Total Cost	
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total		
A. Retrofit Unit Cost: 1-Lamp Electronic Ballast & T8 Lamp								
Electronic Ballast	1	EA	\$21.98	\$21.98	\$25.00	\$25.00	\$46.98	
32W-F32/T8 Lamp	1	EA	Included		\$4.50	\$4.50	\$4.50	
Subtotal				\$21.98		\$29.50	\$51.48	
State Sales Tax	5.5%	%		-		\$1.62	\$1.62	
Subtotal							\$53.10	
Contractor OH & Profit	30.0%	%					\$15.93	
Subtotal							\$69.03	
Bond	1.0%	%					\$0.69	
Subtotal							\$69.72	
Estimating Contingency	10.0%	%					\$6.97	
Total Probable Construction Cost							\$76.70	
B. Retrofit Unit Cost: 2-Lamp Electronic Ballast & T8 Lamps								
Electronic Ballast	1	EA	\$21.98	\$21.98	\$25.00	\$25.00	\$46.98	
32W-F32/T8 Lamp	2	EA	Included		\$4.50	\$9.00	\$9.00	
Subtotal				\$21.98		\$34.00	\$55.98	
State Sales Tax	5.5%	%		-		\$1.87	\$1.87	
Subtotal							\$57.85	
Contractor OH & Profit	30.0%	%					\$17.35	
Subtotal							\$75.20	
Bond	1.0%	%					\$0.75	
Subtotal							\$75.96	
Estimating Contingency	10.0%	%					\$7.60	
Total Probable Construction Cost							\$83.55	
C. Retrofit Unit Cost: 3-Lamp Electronic Ballast & T8 Lamps								
Electronic Ballast	1	EA	\$22.82	\$22.82	\$31.00	\$31.00	\$53.82	
32W-F32/T8 Lamp	3	EA	Included		\$4.50	\$13.50	\$13.50	
Subtotal				\$22.82		\$44.50	\$67.32	
State Sales Tax	5.5%	%		-		\$2.45	\$2.45	
Subtotal							\$69.77	
Contractor OH & Profit	30.0%	%					\$20.93	
Subtotal							\$90.70	
Bond	1.0%	%					\$0.91	
Subtotal							\$91.61	
Estimating Contingency	10.0%	%					\$9.16	
Total Probable Construction Cost							\$100.77	

CONSTRUCTION COST ESTIMATE					Date Prepared January 1994		Sheet Of 2 4	
Project ECIP Facility Energy Improvement				Project No.		Basis for Estimate		
Location Yuma Proving Ground, Arizona				Code A (no design completed)				
Engineer-Architect Keller & Gannon								
Drawing No.			Estimator BIH			Checked By RCL		
Line Item	Quantity		Labor *		Material		Total Cost	
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total		
D. Retrofit Unit Cost: 4-Lamp Electronic Ballast & T8 Lamps								
Electronic Ballast	2	EA	\$21.98	\$43.96	\$25.00	\$50.00	\$93.96	
32W-F32/T8 Lamp	4	EA	Included		\$4.50	\$18.00	\$18.00	
Subtotal				\$43.96		\$68.00	\$111.96	
State Sales Tax	5.5%	%		-		\$3.74	\$3.74	
Subtotal							\$115.70	
Contractor OH & Profit	30.0%	%					\$34.71	
Subtotal							\$150.41	
Bond	1.0%	%					\$1.50	
Subtotal							\$151.91	
Estimating Contingency	10.0%	%					\$15.19	
Total Probable Construction Cost							\$167.10	
F. New Fixture Unit Cost: 2-Lamp Electronic Ballast & T8 Lamps								
Remove Existing Fixture	0.8	MH	\$29.69	\$23.75	-	-	\$23.75	
New Fixture: 2 x 32W-F32/T8 Lamps	1	EA	\$47.50	\$47.50	\$150	\$150.00	\$197.50	
Subtotal				\$71.25		\$150.00	\$221.25	
State Sales Tax	5.5%	%		-		\$8.25	\$8.25	
Subtotal							\$229.50	
Contractor OH & Profit	30.0%	%					\$68.85	
Subtotal							\$298.36	
Bond	1.0%	%					\$2.98	
Subtotal							\$301.34	
Estimating Contingency	10.0%	%					\$30.13	
Total Probable Construction Cost							\$331.47	
H. Retrofit Unit Cost: 3-Lamp Electronic Ballast & T8 Lamps & Specular Reflector								
Electronic Ballast	1	EA	\$22.82	\$22.82	\$31.00	\$31.00	\$53.82	
32W-F32/T8 Lamp	3	EA	Included		\$4.50	\$13.50	\$13.50	
Specular Imaging Reflector	1	EA	\$14.84	\$14.84	\$20.00	\$20.00	\$34.84	
Subtotal				\$37.67		\$64.50	\$102.17	
State Sales Tax	5.5%	%		-		\$3.55	\$3.55	
Subtotal							\$105.72	
Contractor OH & Profit	30.0%	%					\$31.72	
Subtotal							\$137.43	
Bond	1.0%	%					\$1.37	
Subtotal							\$138.81	
Estimating Contingency	10.0%	%					\$13.88	
Total Probable Construction Cost							\$152.69	

CONSTRUCTION COST ESTIMATE					Date Prepared January 1994		Sheet Of 3 4	
Project ECIP Facility Energy Improvement				Project No.		Basis for Estimate		
Location Yuma Proving Ground, Arizona				Code A (no design completed)				
Engineer-Architect Keller & Gannon								
Drawing No.			Estimator BIH			Checked By RCL		
Line Item	Quantity		Labor *		Material		Total Cost	
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total		
I. Retrofit Unit Cost: Occupancy Sensor Lighting Control - Ceiling Mounted								
Ultrasonic Motion Sensor	1	EA	\$22.62	\$22.62	\$86.00	\$86.00	\$108.62	
Sensor Transformer Pack	1	EA	\$15.80	\$15.80	\$30.00	\$30.00	\$45.80	
Wiremold Raceway & 3/C #18 Wire	15	LF	\$2.38	\$35.63	\$0.65	\$9.75	\$45.38	
Subtotal				\$74.04		\$125.75	\$199.79	
State Sales Tax	5.5%	%		-		\$6.92	\$6.92	
Subtotal							\$206.71	
Contractor OH & Profit	30.0%	%					\$62.01	
Subtotal							\$268.72	
Bond	1.0%	%					\$2.69	
Subtotal							\$271.41	
Estimating Contingency	10.0%	%					\$27.14	
Total Probable Construction Cost							\$298.55	
J. Retrofit Unit Cost: Occupancy Sensor Lighting Control - Automatic Wall Switch								
Automatic Wall Switch	1	EA	\$22.62	\$22.62	\$64.00	\$64.00	\$86.62	
Subtotal				\$22.62		\$64.00	\$86.62	
State Sales Tax	5.5%	%		-		\$3.52	\$3.52	
Subtotal							\$90.14	
Contractor OH & Profit	30.0%	%					\$27.04	
Subtotal							\$117.18	
Bond	1.0%	%					\$1.17	
Subtotal							\$118.35	
Estimating Contingency	10.0%	%					\$11.83	
Total Probable Construction Cost							\$130.18	
K. New Fixture Unit Cost: 2-Lamp Compact Fluorescent 2 x 13W/5T4								
Remove Existing Fixture	0.75	MH	\$29.69	\$22.27	-	-	\$22.27	
New Fixture: 2 x 13W/5T4	1	EA	\$43.80	\$43.80	\$45	\$45.00	\$88.80	
Subtotal				\$66.06		\$45.00	\$111.06	
State Sales Tax	5.5%	%		-		\$2.48	\$2.48	
Subtotal							\$113.54	
Contractor OH & Profit	30.0%	%					\$34.06	
Subtotal							\$147.60	
Bond	1.0%	%					\$1.48	
Subtotal							\$149.08	
Estimating Contingency	10.0%	%					\$14.91	
Total Probable Construction Cost							\$163.99	

CONSTRUCTION COST ESTIMATE					Date Prepared January 1994		Sheet Of 4 4	
Project ECIP Facility Energy Improvement				Project No.		Basis for Estimate		
Location Yuma Proving Ground, Arizona						Code A (no design completed)		
Engineer-Architect Keller & Gannon								
Drawing No.			Estimator BIH			Checked By RCL		
Line Item	Quantity		Labor *		Material		Total Cost	
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total		
L. New Fxtr Unit Cost: 2-Lamp Elect. Ballast & T8 Lamps, 2' Surface Mount								
Remove Existing Fixture	0.8	MH	\$29.69	\$23.75	-	-	\$23.75	
Fixture: 2 x 32W-F20/T8 Lamps 24"	1	EA	\$49.88	\$49.88	\$175	\$175.00	\$224.88	
Subtotal				\$73.63		\$175.00	\$248.63	
State Sales Tax	5.5%	%		-		\$9.63	\$9.63	
Subtotal							\$258.25	
Contractor OH & Profit	30.0%	%					\$77.48	
Subtotal							\$335.73	
Bond	1.0%	%					\$3.36	
Subtotal							\$339.09	
Estimating Contingency	10.0%	%					\$33.91	
Total Probable Construction Cost							\$373.00	
M. Install Light Switching for Assembly Rooms - Building 3482								
Explosion Proof Switch: 2 way	2	EA	\$44.80	\$89.60	\$69.00	\$138.00	\$227.60	
Explosion Proof Switch: 3 way	10	EA	\$67.20	\$672.02	\$97.09	\$970.93	\$1,642.95	
Explosion Proof Switch: 4 way	3	EA	\$110.04	\$330.11	\$147.86	\$443.57	\$773.68	
Explosion Proof Switch: 5 way	2	EA	\$152.87	\$305.74	\$197.14	\$394.28	\$700.02	
Junction Boxes	19	EA	\$29.70	\$564.38	\$8.40	\$159.60	\$723.98	
Conduit	925.1	LF	\$2.45	\$2,265.91	\$0.93	\$860.34	\$3,126.25	
Wiring 3 Ea #12 THWN	2775	LF	\$0.32	\$898.54	\$0.20	\$555.06	\$1,453.60	
Wiring #12 Bare Copper	925.1	LF	\$0.27	\$253.37	\$0.06	\$55.04	\$308.41	
Core thru 10" Conc Wall - 1" Dia	12	EA	\$17.55	\$210.56	\$3.56	\$42.72	\$253.28	
Subtotal				\$5,590.23		\$3,620	\$9,209.78	
State Sales Tax	5.5%	%		-		\$199.08	\$199.08	
Subtotal							\$9,408.84	
Contractor OH & Profit	30.0%	%					\$2,822.65	
Subtotal							\$12,231.50	
Bond	1.0%	%					\$122.31	
Subtotal							\$12,353.81	
Estimating Contingency	10.0%	%					\$1,235.38	
Total Probable Construction Cost							\$13,589.19	

* Labor rate based on Means '94 rate including subcontractor OH&P, adjusted for Yuma, AZ.

installation: U.S. Army Yuma Proving Ground, Arizona

project: ECIP Facility Energy Improvements

project number
temporary: _____ program year 1996

permanent: _____ category code 80000

point of contact:

user
name _____ date _____

title _____ phone _____

autovon _____

dfae
name _____ date _____

title _____ phone _____

autovon _____

engineer district
name _____ date _____

title _____ phone _____

autovon _____

other (A-E)
name _____ date _____

title _____ phone _____

autovon _____

reviewed by:

installation facility engineer
name _____ date _____

title _____ phone _____

autovon _____

approved by:

macom engineer
name _____ date _____

title _____ phone _____

autovon _____

project development brochure, PDB-1

facility

ECIP Facility Energy Improvements

**U.S. Army Yuma Proving Ground
Arizona**

**project coordinator for
using service**

**JACK L. NIXON
ENERGY COORDINATOR**

functional requirements summary, PDB-1

1 of 8

PROJECT OBJECTIVE

The objective of this project is to reduce energy consumption and costs and reduce operating costs by implementation of the following retrofits:

- a. Replace two steam boilers with one modular hot water boiler system in Building 506.
- b. Install chilled water temperature reset controls on three chillers (one in Building 506 and two in Building 2105).
- c. Replace the converted 45-ton glycol chiller for ice-on-coil system at Building 506 with an efficient unit designed for cold temperature application.
- d. Install duty cycling controls on four chillers (one in Building 451 and three in Building 3490).
- e. Modify lighting fixtures and install lighting controls as follows:
 - (1) Retrofit fluorescent fixtures with electronic ballasts and T8 lamps in Buildings 451, 506A, 506B, 506C, 2105 and 3490.
 - (2) Retrofit 4-lamp fluorescent fixtures with 3-lamp electronic ballasts, T8 lamps and specular reflectors in Buildings 457, 506B, 2105 and 3490.
 - (3) Replace incandescent fixtures with surface mounted T8 and compact fluorescent fixtures in Buildings 451, 506A and 506B.
- f. Install occupancy sensors (ceiling or wall-switch mounted) in Buildings 451, 506A, 506B, 2105 and 3490.
- g. Install additional (explosion-proof) light fixture switching in Building 3482.

A. SPECIAL CONSIDERATIONS

ITEM		Required or Not Required	To Be * Determined	Comment Attached	Document Attached
A-1	Cost estimates for each primary and supporting facility	R	D		
A-2	Telecommunications system coordination with USACC and authorization for exceptions	NR			
A-3	Coordination with state and local governmental requirements (blind vendors, medical facilities, construction and operating permits, clearinghouse coordination, etc.)	NR			
A-4	Assignment of airspace	NR			
A-5	Economic analysis of alternatives	NR		X	
A-6	Approval for new starts	NR			
A-7	International balance of payments (IBOP) coordination with U.S. European command and NATO—overseas cost estimates and comparables (include rate of exchange used in estimates)	NR			
A-8	Impact on historic places—on site survey by authorized archeologist and coordination with state historic preservation officer and advisory council on historic preservation	NR			
A-9	Exceptions to established criteria	NR			
A-10	Coordination with various staff agencies (Provost Marshall-physical security, etc.)	NR			
A-11	Identification of related or support projects (so projects can be coordinated)	R	A		
A-12	Required completion date	R	A		
Other Special Considerations (List and number items)					
<u>Comment</u> A-5: Economic analysis provided in the Detailed Justification to DD Form 1391.					

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COMMENT ATTACHED — Significant information summarized or explained and attached.

DOCUMENT ATTACHED — Significant information is in an existing document which is attached.

*** BY WHOM** (Check and insert appropriate letter)

A — DFAE

B — Using Service

C — Construction Service

D — Designer

E — Other (Check Comments Attached and explain)

documentation checklist

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DA FORM 5023-A-R, Feb 82

C. ARCHITECTURAL & STRUCTURAL

ITEM		Required or Not Required	To Be * Determined	Comment Attached	Document Attached
C-1	Reconciliation with troop housing programs and requirements	NR			
C-2	Evaluation of existing facilities (including degree of utilization)	NR			
C-3	Approval for removal and relocation of existing useable facilities	NR			
C-4	Evaluation of off-post community facilities	NR			
C-5	Storage and maintenance facilities (including nuclear weapons)	NR			
C-6	Coordination hospitals, medical and dental facilities with Surgeon General	NR			
C-7	Coordination of aviation facilities with FAA	NR			
C-8	Coordination air traffic control and navigational aids with USACC	NR			
C-9	Tabulation of types and numbers of aircraft	NR			
C-10	Evaluation of laboratory, research and development, and technical maintenance facilities	NR			
C-11	Coordination chapels with Chief of Chaplains	NR			
C-12	Review food service facilities by USATSA	NR			
C-13	Automated data processing system or equipment approvals—cost analysis when ADP and/or communication centers not co-located with related facilities	NR			
C-14	Coordination postal facilities with U.S. Postal Service Regional Director	NR			
C-15	Laundry and dry cleaning facilities coordination with ASD(I&L)	NR			
C-16	Tenant facilities coordination with installation where sited	NR			
C-17	Facilities for or exposed to explosions, toxic chemicals, or ammunition—review by DDESB (See also Item B-4)	NR			
C-18	Analysis of deficiencies	NR			
C-19	Consideration of alternatives	NR			
C-20	Determination whether occupants will include physically handicapped or disabled persons	NR			
C-21	As-build drawings for alterations or additions	R			
C-22	Availability of Standard Design or site adaptable designs	NR	C		
	Other Architectural & Structural (List and number items)				

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documentation checklist

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D. MECHANICAL, ELECTRICAL, & UTILITY SYSTEMS

ITEM		Required or Not Required	To Be Determined *	Comment Attached	Document Attached
D-1	Fuel considerations and cost comparison analysis	R	D		
D-2	Energy requirements appraisal (ERA)	R	D		
D-3	Conformance with DOD Energy Reduction requirements	R	D		
D-4	Evaluation of existing and/or proposed utility systems	NR			
	Other Mechanical and Utility Systems (List and number items)				

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documentation checklist

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A. SPECIAL CONSIDERATIONS

ITEM		Required or Not Required	To Be * Determined	Comment Attached	Document Attached
A-1	Factors of risk, restriction or unusual circumstance expected to increase costs beyond applicable area averages	NR			
A-2	Construction phasing requirements	R	A		
A-3	Functional support equipment (mechanical, electrical, structural, and security) to be built in	R	D		
A-4	Equipment in place and justification	NR			
A-5	Other equipment and furniture (O&MA, OPA) and costs	NR			
A-6	Special studies and tests (hazards analyses, compatibility testing, new technology testing, etc.)	NR			
A-7	Type of construction (permanent, temporary, semi-permanent)	NR			
A-8	Government furnished equipment (quantities, procurement time, availability and special handling and storage requirements). Funds used for procurement.	NR			
	Other special considerations (list and number items)	NR			

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technical data checklist

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DA FORM 5024-A-R, Feb 82

C. ARCHITECTURAL & STRUCTURAL

ITEM		Required or Not Required	To Be Determined *	Comment Attached	Document Attached
C-1	Vibration-producing equipment requiring isolation	R	D		
C-2	Seismic zone and other design load criteria (typhoon, hurricane, earthquake loads, high or low loss potential)	NR			
C-3	Protective shelter evaluation and resistant design criteria (conventional/nuclear blast and radiation, chemical/biological)	NR			
C-4	Unusual foundation requirements (pier, pile, caisson, deep foundations, mat, special treatment, permafrost areas, soil bearing)	NR			
C-5	Designation and strength of units to be accommodated	NR			
C-6	Requirements and data for special design projects	NR			
C-7	Unusual floor and roof loads (safes, equipment)	NR			
C-8	Security features (arms rooms, vaults, interior secure areas)	NR			
	Other Architectural & Structural (List and number items)				

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technical data checklist

DA FORM 5024-C-R, Feb 82

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D. MECHANICAL, ELECTRICAL, & UTILITY SYSTEMS

ITEM		Required or Not Required	* To Be Determined	Comment Attached	Document Attached
D-1	Special mechanical requirements or considerations (elevator, crane, hoist, etc.)	NR			
D-2	Special peak usage periods and peak leveling techniques	NR			
D-3	Maintenance considerations (accessibility of equipment, compatibility with existing equipment)	R	B		
D-4	Plumbing—availability, general system type and characteristics (proposed and/or existing, incl. compressed air and gas)	NR			
D-5	Heating—availability, general system type and characteristics (proposed and/or existing)	R	B		
D-6	Ventilating, air condition/refrigeration—availability, general system type and characteristics (proposed and/or existing)	R	B		
D-7	Electrical—availability, general system type and characteristics incl. airfield lighting, communication, etc. (proposed and/or existing)	NR			
D-8	Water supply/waste treatment—availability, general system type and characteristics (proposed and/or existing)	NR			
D-9	Energy requirements/fuel conversion (sources, availability, loads, types of fuel, etc.)	R	B		
D-10	Solar energy evaluation	NR			
	Other Mechanical & Utility Systems (List and number items)				

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DA FORM 5024-D-R, Feb 82

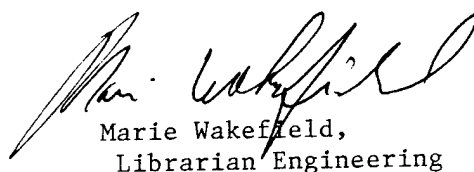


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